Type of presentation: Oral

MS-4-O-1581 Healing kinetics of voids in an Al-Mg-Er alloy investigated by in situ transmission electron microscopy and electron tomography

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Extensive researches have revealed that stress concentration and crack nucleation usually take place around defects such as voids under external loadings, which would greatly shorten the incubation period of crack initiation. Voids also have adverse effects on the fatigue crack propagation and crack closure, while most of mechanical fractures in engineering are reportedly related to fatigue crack initiation and growth in metals. Therefore, investigations on the evolution of voids in materials have attracted great interests, and these investigations help to understand the recovery mechanism of materials properties, and consequently to improve the qualities of materials and to guide the development of processing techniques.

Using *in situ* transmission electron microscopy and electron tomography, we have studied the healing kinetics of voids with the dimension of submicron-scale embedded in a cold-rolled Al-Mg-Er alloy. The results show that voids are healed successfully within 50 minutes at a relative low temperature of 453 K. Quantitative analysis of the *in situ* micrographs reveals three stages for the void healing process: an initial fast-healing stage, then a constant healing stage, and finally a rapid-healing stage. The different healing rates are likely caused by varying surface curvatures due to the evolution of void morphology during the healing process. The entire evolution process of voids healing is actually completed together by surface diffusion, lattice diffusion and interface diffusion. However, as the voids are embedded inside Al alloy grains, lattice diffusion is considered to dominate the whole healing process. Mg enrichment was observed at the healed voids immediately after the healing. This indicates that the faster diffusion of magnesium atoms in aluminum matrix enhances the void healing in the Al-Mg-Er alloy, which is particularly essential for the void healing at low temperatures. The fatigue resistance and plasticity of the cold-rolled Al alloy are improved significantly after the annealing at 473 K.

References

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Acknowledgement: The authors acknowledge financial support from the Special Funds for the Major State Basic Research Projects of China (Grant No. 2012CB619503) and the Natural Sciences Foundation of China (Grant Nos. 51171188, 51390473, 51221264, and 11332010).

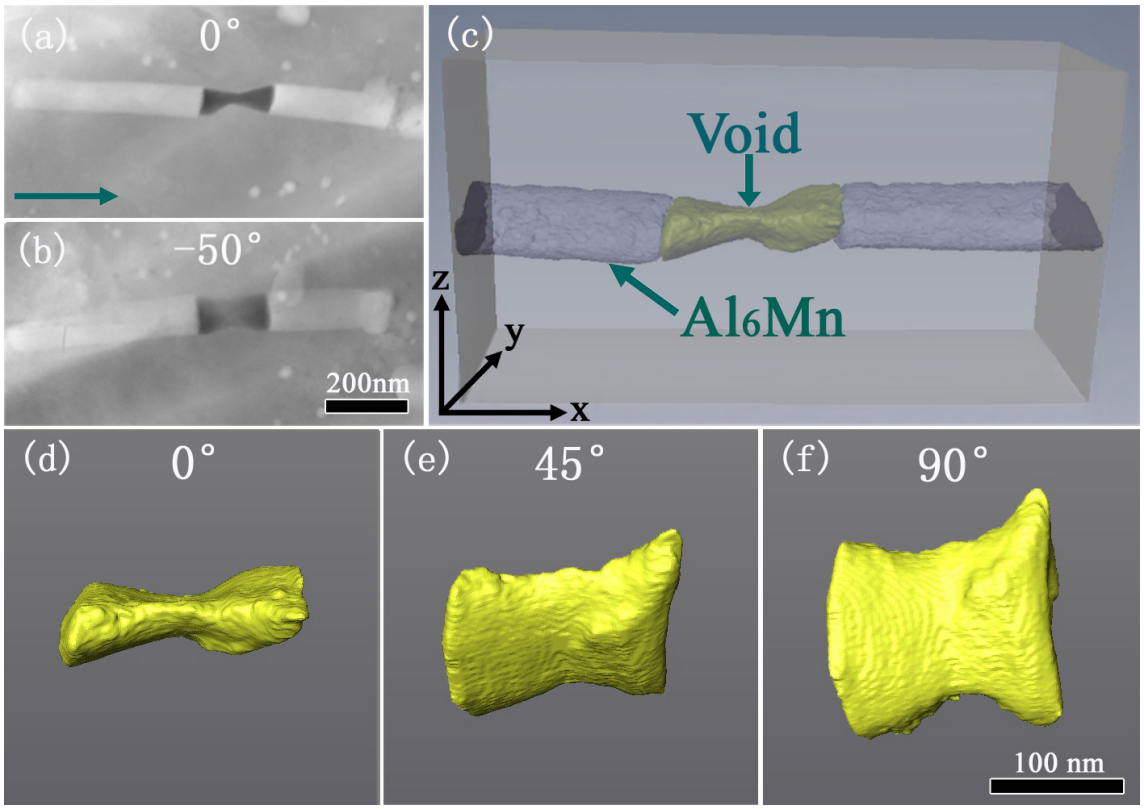

Fig. 1: HAADF STEM image and reconstructed surface renders of a void between Al_6Mn precipitates embedded in Al matrix. (a, b) HAADF images of the void with 0° and -50° tilting. (c-f) Surface renders of the void (gold) and the Al_6Mn precipitates (purple) at two sides, obtained with electron tomography, while all of them are embedded in an Al matrix.

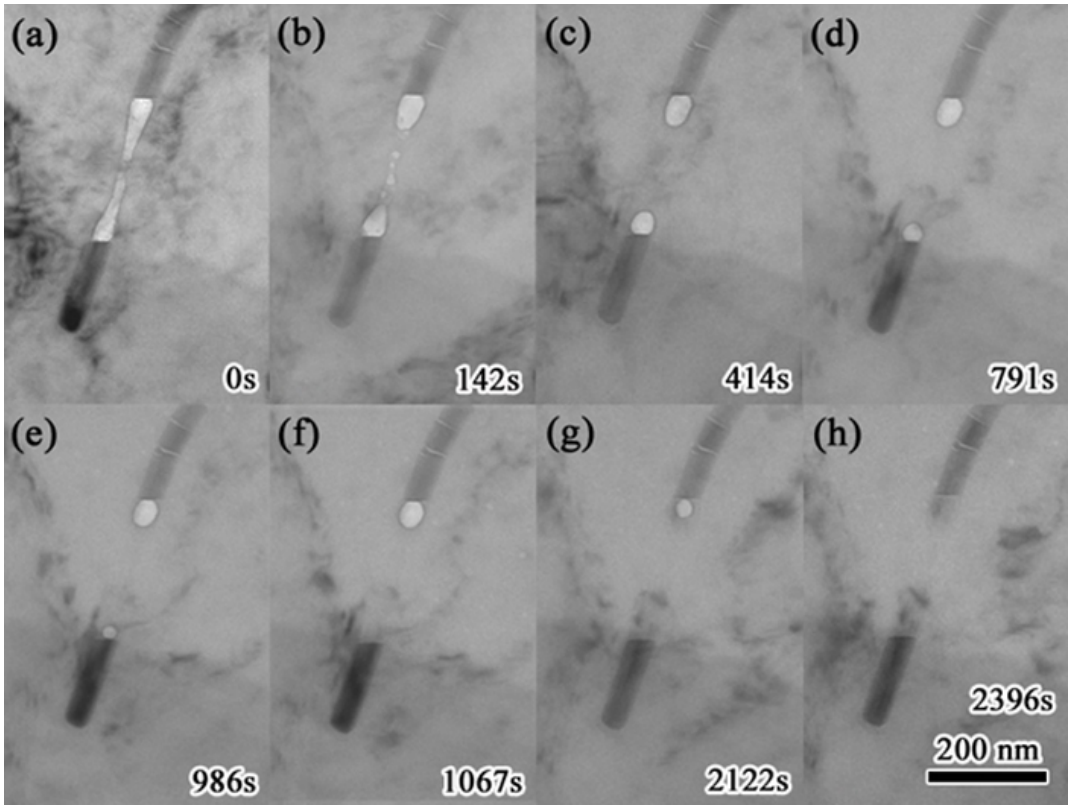

Fig. 2: The healing evolution process of voids embedded in the cold-rolled Al alloy during the in situ heating experiment.